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TECHNICAL EFFICIENCY OF COWPEA PRODUCTION IN OSUN STATE NIGERIA

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ABSTRACT
This paper presents the analysis of technical efficiency of cowpea farmers in Osun State Southwest Nigeria, using the stochastic production frontier. The farmers' average technical efficiency is 87%, which suggest an appreciable use of inputs in productivity. Analysis of technical efficient and some socio-economic variables using tobit regression model is found to be significantly different from zero at 1% for cooperative membership and farming experience. These are farm size, seed, hired labour, family labour, fertilizer and pesticides. It is suggested that farmers should be encouraged to join cooperative society and extension services agents should intensify their efforts in training and mobilizing farmers for improved production of cowpea. The variables- farm size, seed, hired labour, family labour, fertilizer and pesticides.
Keywords: Scale Efficiency, Technical Efficiency, Cowpea Production, Stochastic Frontier, Tobit Model and Marginal Products.

INTRODUCTION

The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers alike. It is no surprise therefore, that considerable effort has been devoted to the analysis of farm level efficiency in developing countries, Nigeria inclusive. An underlying premise behind much of this work is that if farmers were not making efficient use of existing technology, then efforts designed to improve efficiency would be more cost effective than introducing new technologies as a means of increasing agricultural output. (Belbase and Grabowski, 1985). The efficiency of a farm/firm refers to its success in producing as large amount of output as possible given a set of inputs. To determine the efficiency of a particular firm, there need for efficiency measurement through the production factor inputs and processes. This (efficiency measurement) has received considerable attention from both theoretical and applied economists. From a theoretical point of view, there has been a spirited exchange about their relative importance of the various components of firm efficiency (Leibenstein 1966, 1978; Comanor and Leibenstein, 1969). From an applied perspective, measuring efficiency is important because this is the first step in a process that might lead to substantial resource savings these resource savings have important implications for both policy formulations and firm management (Bravo-Ureta and Rieger,1991).

M.J Farrell originated the current interest in efficiency measurements. Farrell (1957) proposed an approach that distinguishes between technical and allocative efficiency. Technical efficiency refers to the ability of producing a given level of output with a minimum quantity of inputs under a given technology. Allocative efficiency refers to the choice of the optimal input proportions given relative prices. Economic or total efficiency is the product of technical and allocative efficiency. Farrell's model, which is known as a deterministic nonparametric frontier (Forsund, *et al*, 1980), attributes any deviation from the frontier to inefficiency and imposes no functional form on the data. Several extensions of Farrell deterministic model have been made by economists such as Aigner and Chu, (1968) Afriat, (1972) Richmond, (1974) Schmidt, (1980) and Greene, (1980) among others.

A deficiency characterizing all deterministic frontier models is their sensitivity to extreme observations. A more recent approach for measuring efficiency, which seeks to ameliorate the extreme observation problem, is the stochastic frontier model developed by Aigner, *et al*, (1977) and by Meeusen and van deu Broeck, (1977).

The stochastic frontier model assumes an error term with two additive components- a symmetric component that accounts for pure random factors, and a one-sided component which captures the effects of inefficiency relative to the stochastic frontier.

In general, a firm is technically efficient if its observed production outlay (y^o, X^o) exactly satisfies the Cobb-Douglas production equation given as $y^o= f(X^o)$, where f is the production frontier, y^o is the output and X^o is a vector of input for the firm. The firm is technically inefficient if $y^o < f(X^o)$ that is, the firm operates inside the production frontier.

The firm is allocatively efficient if the ratio of the marginal products $MP_{(x)}$ between all input equal to the ratio of the input prices MPi/MPi = Pi/Pi

TABLE 1: MAXIMUM LIKELIHOOD PARAMETER ESTIMATES OF STOCHASTIC PRODUCTION FRONTIER

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T-STATISTICS
Intercept	0.8952	0.0232	38.55
Farm size	0.0282	0.0246	1.44
Age	-0.0004402	0.000366	-1.20
Sex	0.012	0.0075	1.60
Extension awareness	0.00624	0.009313	0.67
Education	0.008405	0.010263	0.795
Cooperative membership	0.0219***	0.007449	2.94
Farming experience	0.00167***	0.0005529	3.02
Log likelihood function 211.35			
Chi-square 41.12, N= 120			

*** Statistically significant at 1%

Scale efficiency is achieved if the firm produces at a marginal cost that is the same as the price of the output. Allocative and scale efficiency is the conditions for profit maximization and is labeled price efficiency.
This paper contributes to the efficiency literature in developing country agriculture by quantifying the level of technical efficiency for a sample of cowpea farmers in Osun State, Southwest Nigeria.

ANALYTICAL FRAMEWORK

In the analysis of the data for cowpea producing farmers, stochastic production frontier was employed- using the variant of the stochastic production analysis adopted by Coelli and Battese, (1996), Bravo Ureta and Rieger, (1991) and Dawson *et al*, (1991).
It is assumed that the farm frontier production function can be written as:

$$Q = f(X_i;\beta)\text{...}(1)$$

Where Q is the quantity of cowpea output, X_i is a vector of input quantities, and β is a vector parameter.

The empirical model of the stochastic production function frontier applied in the analysis of efficiency of the production system of the cowpea production is specified as:

$$\ln Y_{ij} = \ln\beta_o + \beta_1 \ln X_{1ij} + \beta_2 \ln X_{2ij} + \beta_3 X_{3ij} + \beta_4 X_{4ij} + \beta_5 X_{5ij} + \beta_6 X_{6ij} + \in \text{...........}(2)$$ Where

Y=total output (kg)
X_1=Farm size (ha)
X_2=quantity of seed (kg)
X_3=amount spent on hired labour (₦)
X_4=family labour (maydays)
X_5=fertilizer (kg)
X_6=pesticides (litres)

Subscript i and j refer to the i^{th} cowpea produce and the jth input respectively and $\in = V_{ij} - U_{ij}$ is the composed error term (Aiger *et al, (*1977); Meeiisen and Van deu Broeck, 1977). The two components v and u are assumed to be independent of each other, where v is the symmetric (two-sided) component, normally distributed random error

(V~N $(0,\sigma^2_v)$ which capture variations in output due to factors outside the control of the farmer like fluctuations in input/prices and u is the one-sided efficiency component with a half-normal distribution (U~ | N $(0,\sigma^2_u$ |) which is non –negative random variable called technical inefficiency effect associated with the technical efficiency of cowpea production and it capture the variation in output due to family size, age, educational status, cooperative membership, farmers experience(yrs) and other socio-economic characteristics. U_{ij} equal zero for any output lying on the frontier while $U_{ij} > 0$ for any output lying below the frontier. Hence,

$$\sigma^2 = \sigma^2{}_v + \sigma^2{}_u \text{.................................}(4)$$

TABLE 2: STOCHASTIC PRODUCTION FRONTIER FOR DETERMINANTS OF COWPEA OUTPUT OF FARMERS IN OSUN STATE

VARIABLE	ML PRODUCTION FRONTIER ESTIMATES	STANDARD ERROR
Intercept	4.4126	0.0000251
Farm size	0.6593***	0.0000178
Seed	0.0540***	0.0000199
Hired labour	0.0843***	0.00000140
Family labour	0.1801***	0.00000633
Fertilizer	0.1087***	0.00000673
Pesticide	0.0367***	0.00000417
Log likelihood 48.7948		
Wald Chi-square 8.056e +10, N= 120		

***Statistically significant at 1%.

However, the output variable in the stochastic frontier production function is output in kg, the measures of technical efficiencies obtained will, of course, be measures of the overall technical efficiencies of the cowpea farmers. It is assumed that the inefficiency effects are independently distributed and U_{ij} arises by truncation (at zero) of the normal distribution with mean U_{ij} and variance.

The linear tobit regression model was used to analyze the effect of certain socio-economic factors on the technical efficiency of the farmer. The model was used because the dependent variable technical efficiency scores are censored having values ranging between 0 and 1 (Llewenlyn and Williams (1996); Amara *et al* (1999). The model specification is given as:

$$TE = f(X_1, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, e_t)\text{....................}(5)$$

Where TE is the technical efficiency index for farmer i
X_1 = Farm size (ha)
X_7 = Age of the farmers (yrs)
X_8 = Gender grouping; male=1, otherwise=0
X_9 = Extension awareness/visitation; awareness=1, otherwise=0
X_{10}= Level of education; Dummy variable; if educated= 1, otherwise =0
X_{11}= Cooperative membership; membership =1, otherwise =0
X_{12}= Farmers' farming experience (yrs)
e_t = The error term

DATA AND EMPERICAL PROCEDURES

The data used in this paper come from a random sample of 120 cowpea farmers in Osun State, southwest Nigeria, for the 2004/2005 agricultural growing seasons. The sample comprised of a random sample of six farm-villages with

an average of 20 cowpea farmers within each sample village. The data were collected using structured questionnaires tailored to obtain information on input – output production activity of each farm-firm.

The Cobb-Douglas functional form was used to estimate the technical efficiency in the stochastic production frontier. The specific model estimated is the following:

$$\ln Y = \ln \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \in \text{.............................}(6)$$

Where $Y, \beta s$ and $X_i\,(_i = 1,2,3..........6)$ are as defined earlier (eq. 2)

TABLE 3: AVERAGE TECHNICAL EFFICIENCY (TE) INDICES AND SOCIO-ECONOMIC CHARACTERISTICS FOR COWPEA FARMERS

VARIABLE	N	PERCENTAGE (%)	TECHNICAL EFFICIENCY (TE)	MEAN TE
SIZE (ha)				
≤0.10	25	20.8	0.93	
>0.10≤0.30	50	41.7	0.98	0.94
>0.30≤0.50	30	25.0	0.93	
>0.50	15	12.5	0.92	
AGE (years)				
≤40	20	16.7	0.94	
>40≤50	34	28.3	0.94	0.93
>50≤60	35	29.2	0.91	
>60	31	25.8	0.92	
GENDER				
0	18	15.0	0.82	0.87
1	102	85.0	0.92	
EXTENTION				
0	98	81.6	0.75	0.90
1	22	18.4	0.96	
EDUCATION				
0	29	24.2	0.85	0.90
1	91	75.8	0.95	
COOPERATIVE				
0	75	62.5	0.40	0.66
1	45	37.5	0.93	
EXPERIENCE (YEARS)				
≤10	67	55.8	0.92	
>10≤20	24	20.0	0.73	0.86
>20≤30	17	14.2	0.83	
>30	12	10.0	0.98	

Mean Technical Efficiency =0.87

The Tobit regression model was used in the analysis for the socio-economic attribute(s), which affects the technical efficiency in the stochastic production frontier. The Tobit model is given as the following:

$$TE = f(X_1, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, e_t)\text{.....................................}(7)$$

Where $TE, X_i\,(_i = 1,7,8...........12)$ and e_t are as stated in the previous section (eq. 5).

Descriptive statistics for the variables used in the analysis are given in table 3.

EMPIRICAL RESULTS

Tobit regression model estimates of equation 5 are presented in Table3.

Maximum likelihood estimates of the stochastic production frontier are represented in Table 1.

All parameter estimates were statistically insignificant at the 1% significance level except for cooperative membership and years of farming experience. The coefficient of cooperative membership has the higher value (elasticity). This suggests that productivity would be higher when farmers belong to cooperative societies. This agrees with the findings of Onyenwaku and Fabiyi (1991). The farming experience gathered over the years of practices was found to significantly enhance the level of cowpea production. Age of farmers have a negative relationship with the technical efficiency. However, the important factor is the number of years the farmer has being cultivating cowpea regardless of other crops. This implies that a unit increase in farming experiences leads to a better assessment of the important and complexities of good farming decision-making including efficient use of input.

The stochastic production regression analysis (Table 2) revealed that 10 percent increase in farmland area cultivated given the set of inputs-seed, hired labour, family labour, fertilizer and pesticide will correspond to an increase in output of cowpea with 6.593, 0.54, 0.84, 1.8, 1.1, and 0.37 percent respectively. This shows that the output of cowpea is inelastic to the inputs used in the area. Furthermore, the scale co-efficient is 1.12 signifying increasing returns to scale of cowpea production. Based on this, the null hypothesis of constant returns to scale can be rejected.

The farmland area cultivated contributed the highest value, 94%, to the overall technical efficiency in cowpea production (Table 3). However, the age of the farmers has 93% input to the efficiency but reduces to an average of 90%, as the farmer grows old. 53% of the male cowpea farmers were technically efficient out of the total 87% of the gender contribution to production efficiency. Awareness on the latest technology in cowpea production through extension services was 56% out of 90% efficiency level in the mode of production. The level of education is a 56% educated farmer contributing 90% efficiency in the production of cowpea. Farmers, belonging to a cooperative society were 46% efficient and non-cooperative members were just 20% efficient. Farmers experience in cowpea production amounts to 86% efficiency level of the overall technical efficiency of cowpea production. Average technical efficiency in the study area is estimated as 87%.

CONCLUDING REMARKS

This study estimates stochastic frontier production for cowpea farmers in Osun State, southwest Nigeria. This analysis shows that farm size (land), cooperative membership and farming experience are the major contributing factors to the efficient production of cowpea in the state. Other variables such as seed (kg), hired labour (naira), family labour (maydays), fertilizer (kg), and pesticides (litres) were found to exact positive effect on the production of cowpea.

The result of the study suggests that if farmers should join cooperative society and the plot of the land used for cowpea should increase with adequate farming experience, these would enhance the productivity level of the farmers.

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